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## 9.0 ELECTRICAL SYSTEMS

**Learning Objectives:**

1. State the purposes of the following:

    a. Emergency power supply system
    b. Normal power supply system
    c. Class 1E uninterruptible power supply system
    d. 12-hour uninterruptible power supply system
    e. Non-Class 1E uninterruptible power supply system
    f. Station blackout diesel generators

2. Describe the major differences between the electrical system design of the US-EPR and those of currently operating PWRs.

## 9.1 Overview

### 9.1.1 Offsite Power System Description

Offsite power to the US-EPR is provided by at least two utility transmission lines connected to the station switchyard. The power plant interfaces with the switchyard at the output of the main generator via the main step-up transformers and at the station auxiliary transformers.

The utility transmission system, locations of right of way, transmission lines and towers, and switchyard design and interconnections are site specific. A COL applicant that references the US-EPR design certification will provide site-specific information describing the interfaces between the offsite transmission system and the nuclear unit, including switchyard interconnections.

During normal operation, the main generator connects to the switchyard via three single-phase step-up transformers to supply power to the transmission system. The plant electrical distribution system receives offsite power during normal plant operating modes, anticipated operational occurrences, and postulated accidents via four auxiliary transformers connected to the switchyard. The US-EPR design does not include the traditional unit auxiliary transformer that connects the plant electrical distribution system directly to the main generator output as the normal source during power operation. The preferred power supply (PPS) from the transmission system to the Class 1E emergency power supply system (EPSS), which provides power under accident and post-accident conditions, consists of two emergency auxiliary transformers (EATs), which provide power from the switchyard to the EPSS with no intervening non-Class 1E switchgear. Two normal auxiliary transformers (NATs) provide power from the switchyard to the non-Class 1E normal power supply system (NPSS).

### 9.1.2 Onsite Power System Description

The EPSS distributes 6.9-kV and 480-Vac power to safety-related and selected nonsafety-related plant loads. There are four divisions of switchgear, load centers, motor control centers (MCCs), standby power sources, and distribution system transformers that make up the EPSS, as shown in Figure 9-1. Each division includes a Class 1E emergency diesel generator (EDG), which is the standby power source to its particular division in the event of a power loss. Each division has the ability to connect to one of two nonsafety-related station blackout diesel generators (SBODGs), which serve as alternate ac (AAC) sources during station blackout (SBO) conditions. An alternate feed is provided from EPSS division 2 to EPSS division 1 to supply a standby source of power to required safety-related systems, safety-related support systems, or components that do not have four 100%-redundant trains when the EPSS division 1 EDG or certain portions of the EPSS division 1 electrical distribution system are not available. A similar alternate feed provides standby power to EPSS division 2 from EPSS division 1 when the EPSS division 2 EDG or certain portions of the EPSS division 2 electrical distribution system are not available. Similar alternate feeds are provided between EPSS division 3 and EPSS division 4. Alignment of an alternate feed is completed manually to satisfy single-failure criteria when certain electrical components, including EDGs, are out of service.

Each EDG automatically starts and connects to its EPSS 6.9-kV switchgear when a loss-of-power or a degraded-voltage condition is detected at the respective division supply bus. An automatic start will also occur if a safety injection signal (SIS) is initiated from the protection system. The required safety-related loads are automatically sequenced onto the EDG when the generator has obtained nominal speed and voltage and a loss-of-voltage or a degraded-voltage signal has been received. Each EDG has the capacity and capability to power the required safety-related loads when its associated division serves as an alternate feed for another division.

The Class 1E uninterruptible power supply system (EUPS) has four separate and redundant 250-Vdc divisions that provide power to EUPS dc loads and to inverters that power safety-related and select nonsafety-related loads. The EUPS inverters provide three-phase 480-Vac power to Class 1E MCCs that supply safety-related loads, including power to instrumentation and control via ac/dc converters. The EUPS configuration is shown in Figure 9-2. One of the SBODGs can power a division’s in-service EUPS battery charger during SBO conditions.

The NPSS distributes 13.8-kV, 6.9-kV, and 480-Vac power to nonsafety-related loads throughout the power plant, including the reactor coolant pumps, as shown in Figure 9-3. The system is configured in four trains of switchgear, load centers, MCCs, and distribution system transformers. Trains 1 and 2 provide the connection points for the SBODGs. The SBODGs provide power to selected Turbine Island equipment for asset protection if necessary during loss-of-power events, and to the EPSS during SBO conditions.

The two SBODGs are non-Class 1E diesel generators that serve as AAC sources that can be aligned to selected EPSS buses to maintain the power plant in a safe-shutdown condition during postulated SBO conditions. Each SBODG automatically starts in response to a loss of voltage on its respective 6.9-kV NPSS bus, and it is manually aligned to the assigned EPSS bus to provide power to the EPSS during an SBO.

The 12-hour uninterruptible power supply system (12UPS) provides uninterruptible power for nonsafety-related Nuclear Island and Turbine Island loads and for instrumentation and control systems. Figure 9-4 shows the system batteries, battery chargers, inverters, and system connections. The 12UPS battery chargers are powered from the SBODGs during loss-of-power conditions.

The non-Class 1E uninterruptible power supply system (NUPS) provides uninterruptible power for nonsafety-related ac and dc Turbine Island loads and dc power to the control rod drive mechanism operating coils in the Nuclear Island. The NUPS batteries, battery chargers, and inverters are shown in Figure 9-5. The NUPS battery chargers are powered from the SBODGs during loss-of-power conditions.

### 9.1.3 Design Bases

#### 9.1.3.1 Offsite Power System

Station power is provided by a minimum of two offsite transmission lines, each with the capacity and capability to maintain core cooling and containment integrity, as well as other safety-related functions, during postulated events. Each offsite source to the EPSS buses is immediately available in the event of a loss of the other offsite power source.

Physical separation is provided between the two offsite power sources to minimize the possibility of simultaneous failure during normal operations and postulated accident and environmental conditions.

The normal power supply to safety-related and nonsafety-related loads is the switchyard via the station auxiliary transformers. This arrangement eliminates the need for bus transfers during startup and shutdown operations.

The EAT alignment to the Class 1E divisional buses utilizes no intervening non-Class 1E buses, and Class 1E buses do not share common windings with the transformers supplying the non-Class 1E switchgear.

The NAT supplies to the NPSS provide both normal and alternate offsite power supplies to the nonsafety-related plant loads.

Each EAT is normally aligned to two EPSS divisions, and each serves as the alternate power source for the other two EPSS divisions. Each EAT is sized to provide power to the loads in all four EPSS divisions under postulated design-basis conditions.

The NATs are sized to provide power to the nonsafety-related loads during power plant operations. Both NATs are normally in service. Each NAT is sufficient to power all four of the NPSS trains to allow for NAT maintenance or for the transfer of loads due to a NAT failure.

#### 9.1.3.2 Onsite Power System

The onsite Class 1E distribution system has the capacity and capability to supply power to the safety-related loads to mitigate design-basis accident conditions with a concurrent loss of offsite power (LOOP).

The onsite Class 1E distribution system has four redundant divisions. This degree of redundancy maintains power to safety-related loads to complete required safety-related functions in the event of a single failure. Electrical independence and physical separation are provided between redundant onsite Class 1E distribution divisions, so that a failure in one division does not prevent the completion of safety-related functions.

Each of the four onsite Class 1E distribution divisions, consisting of switchgear, load centers, MCCs, batteries, and inverters, are contained in Seismic Category I structures. The Class 1E equipment is qualified as Seismic Category I and can withstand seismic design-basis loads without loss of safety-related function.

The EUPS batteries are sized to provide power for two hours to loads connected to the Class 1E distribution equipment and required to place and to maintain the plant in the safe-shutdown condition, without utilization of the battery chargers. The EUPS battery chargers are sized to supply continuous steady-state loads while recharging their respective batteries.

Each EDG is sized so that it can supply standby power to loads connected to Class 1E distribution system equipment in its respective division and to loads aligned to another EPSS division during alternate-feed implementation for safe plant shutdown following a design-basis accident with a LOOP.

Each EDG automatically starts as determined by an undervoltage or degraded-bus-voltage condition on its respective Class 1E EPSS bus. The EDG load sequencer properly applies the large loads to the EDG. An SIS will cause the EDG to automatically start, attain rated speed and voltage, and remain in a ready-to-load condition.

Class 1E electrical isolation devices are provided where non-Class 1E circuits connect to Class 1E systems. The isolation devices prevent, to the extent practical, faults or other failures in the non-Class 1E circuits from degrading the Class 1E circuits below acceptable levels.

Alternate feeds are provided between EPSS divisions to provide normal and standby power to required safety-related systems, safety-related support systems, or components that do not have four 100%-redundant trains when certain electrical components, including EDGs, are out of service.

Physical and electrical separation is maintained between redundant Class 1E cables and between Class 1E and non-Class 1E cables so that a single cable or equipment fault will not prevent completion of a required safety-related function, and a non-Class 1E cable fault will not affect redundant Class 1E circuits.

Two SBODGs are provided as AAC sources to mitigate postulated SBO conditions.

## 9.2 Offsite Power System

### 9.2.1 Description

The offsite power system provides power from the transmission system, via the station switchyard, to the plant Class 1E and non-Class 1E electrical distribution systems. The offsite power system includes all transmission lines connected to the switchyard, the switchyard equipment (overhead buses, circuit breakers, disconnect air switches), and auxiliary transformers, and ends at the input terminals of the switchgear circuit breakers. The offsite transmission system and connections to the station switchyard are site specific. A COL applicant that references the US-EPR design certification will provide site-specific information regarding the offsite transmission system and connections to the station switchyard.

The switchyard has connections to at least two transmission lines. The normally energized transmission lines are physically independent circuits that minimize the likelihood of their simultaneous failure under operating and environmental conditions and postulated events, including transmission tower or transmission line failure. These lines do not cross, and no other transmission lines cross above these two lines. Each offsite power circuit is sized to supply the station safety-related and nonsafety-related loads during normal and abnormal operation.

The PPS supplies the station Class 1E emergency power supply system buses from two independent overhead lines between the switchyard and the station transformer area via two emergency auxiliary transformers. The station remains connected to the offsite power sources during normal plant operation regardless of main generator status, without transferring buses or power sources during startup, full power operation, or shutdown. Each PPS circuit is normally in service through its respective EAT.

Two additional overhead lines provide power via two normal auxiliary transformers to the station non-Class 1E normal power supply system buses.

Each EAT supplies the alternate power to the EPSS buses supplied by the other EAT. Each EAT has sufficient capacity to supply all four EPSS divisions during postulated events to support core cooling and containment integrity and to maintain other safety-related function capability. An EAT failure results in the other EAT power source automatically accepting the load of the EPSS buses originally connected to the failed EAT.

The two normally in-service NATs provide power to four NPSS 13.8-kV trains. The offsite sources to the NPSS switchgear are arranged so that there is an alternate supply to each bus (similar to the EAT configuration).

A COL applicant that references the US-EPR design certification will provide site-specific information regarding the communication agreements and protocols between the station and the transmission system operator, independent system operator, or reliability coordinator and authority. Additionally, the applicant will provide a description of the analysis tool used by the transmission system operator to determine, in real time, the impact that the loss or unavailability of various transmission system elements will have on the capability of the transmission system to provide post-trip voltages at the switchyard. The information provided will be consistent with information requested in NRC Generic Letter 2006-02.

Indications available in the main control room (MCR) which indicate the capability of the PPS to perform its intended function include:

- Status indication (open/close) of the incoming PPS supply breakers at the EPSS switchgear,
- Undervoltage alarms for the Class 1E uninterruptible power supply system, which provides the control power to the PPS supply breakers at the EPSS switchgear,
- Degraded-voltage alarm, when a degraded voltage is sensed at an EPSS bus which is connected to the PPS, and
- PPS voltage indication.

The US-EPR does not use an automatic load dispatch system, which eliminates the potential for any interference from such a system with safety-related actions that may be required of the protection system.

### 9.2.2 Station Switchyard

The switchyard layout is site specific. A COL applicant that references the US-EPR design certification will provide site-specific information for the switchyard layout design.

The switchyard provides the connections between the transmission lines, for the main generator output, for the PPS to the EPSS buses, and for the offsite power supply to the NPSS buses. The switchyard provides independent circuits and connections for the main step-up transformers (MSUTs), the two NATs, and the two EATs. Additionally, each of the two circuits which connect the switchyard with the EATs has the capacity and capability to meet the power requirements of the safety-related loads for the four divisions of the EPSS during accident and post-accident conditions.

The MSUTs and auxiliary transformers have a deluge fire protection system that provides a distribution spray pattern over the respective transformer for fire suppression. The deluge system is automatically actuated by a heat-sensing device located at the perimeter of the respective transformer, or manually activated from the transformer valve station. Additionally, each transformer has an oil retention pit.

## 9.3 Onsite Power System

### 9.3.1 AC Power Systems

The main generator provides power through the station switchyard to the transmission system via an isolated phase bus (IPB) system and three single-phase main step-up transformers. Incoming power to the onsite ac power system is from the station switchyard during all modes of plant operation, through the emergency and normal auxiliary transformers, to the Class 1E and non-Class 1E distribution systems, respectively.

The main generator is connected to the switchyard via two circuit breakers in the switchyard. Either breaker enables the generator to provide power to the transmission system. Prior to main generator synchronization with the transmission system, the plant loads are fed by the transmission system through the switchyard. The main generator circuit breakers in the switchyard are open at this time. The switchyard and offsite power supply arrangement allows station loads to remain powered from the same source during all plant operating modes and eliminates the need for bus transfers during plant startup or shutdown.

Main generator protection is provided by primary and backup protection schemes. Protective device actuation trips the main generator output breakers in the switchyard, trips the generator excitation, and initiates a turbine trip. Main generator protection features include stator overcurrent, ground fault, and reverse power.

The MSUT protection detects faults and initiates protective actions to minimize any potential damage to an MSUT, while minimizing impact to the electrical distribution system. Protective devices installed for the protection of the MSUT include transformer bank differential current, ground fault overcurrent, phase overcurrent, and sudden pressure relays. Activation of an MSUT protection device results in a turbine-generator trip and a separation of the main generator from the grid by tripping the main generator breakers in the switchyard. The onsite electrical distribution continues to be powered from offsite through the switchyard with no power interruption to the onsite power distribution system. No offsite power source transfer is required during this transient.

If the offsite transmission system has a fault that results in a loss of power from the transmission system, the main generator continues to provide power to the plant loads from the switchyard via the normal and emergency auxiliary transformers. The main generator is designed to accept a load rejection without a turbine trip and to continue to supply plant loads without interruption.

The onsite ac power supply system supplies all electrical loads of the plant and is subdivided into the Class 1E emergency power supply system and the non-Class 1E normal power supply system. The EPSS supplies electrical power to safety-related loads and to a limited number of nonsafety-related loads. The NPSS supplies electrical power to the remaining plant nonsafety-related loads.

The onsite distribution system, including the main generator, transformers, buses, bus feeder breakers, and their connections, is shown in Figures 9-1 and 9-3. The nominal ratings of the ac power system main components are listed in Table 9-1. Nominal bus voltages used in the onsite ac distribution system are 13.8 kV, 6.9 kV, 480 Vac, 208 Vac, and 120 Vac.

#### 9.3.1.1 Emergency Power Supply System

The purpose of the EPSS is to distribute power to 6.9-kV and 480-Vac safety-related loads and to a limited number of nonsafety-related plant loads. The EPSS has four divisions. Each division includes 6.9-kV switchgear, 480-Vac load centers (LCs), and 480-Vac MCCs, as shown in Figure 9-1.

Each division of EPSS distribution equipment is located in a respective Seismic Category I safeguard building (SB), essential service water pump building (ESWPB), or diesel generator building, each of which provides physical separation for redundant equipment. The EPSS Class 1E switchgear buses, LCs, MCCs, distribution transformers, and other Class 1E components meet the Seismic Category I requirements of RG 1.29. This physical design also facilitates access control to Class 1E power equipment areas.

Power to the EPSS is received from offsite power via two separate and independent circuits from the station switchyard through two emergency auxiliary transformers, 30BDT01 and 30BDT02. The EATs are three-phase, three-winding, core-type, oil-immersed power transformers with two identically rated 6.9-kV secondary windings. Transformer 30BDT01 normally powers distribution buses 31BDA and 33BDA, while 30BDT02 normally powers 32BDA and 34BDA.

The station remains connected to the offsite power sources without transferring buses or power sources during startup, full-power operation, or shutdown. Each offsite preferred power source is normally in service through its respective EAT. The EPSS connections with offsite power utilize no intervening non-Class 1E buses and do not share common windings from the preferred-power EATs with the non-Class 1E switchgear. This arrangement minimizes the probability that transients involving nonsafety-related loads will adversely affect the Class 1E equipment and eliminates additional failure points between the offsite source and the Class 1E equipment.

The EAT protection detects faults and initiates protective actions to minimize any potential damage to an EAT, while minimizing impact to the electrical distribution system by isolating the affected transformer in the event of a transformer fault. Protection devices installed for EAT protection include transformer differential, ground fault overcurrent, phase overcurrent, and sudden pressure relays. An EAT-related fault initiates an automatic fast transfer of the offsite power source for the affected bus to the unaffected EAT. The combined loads of all four EPSS divisions under postulated conditions are within the ratings of each of the EATs. The fast transfer minimizes voltage decay and frequency difference to limit motor torque during the transfer, thus minimizing equipment degradation.

EPSS divisions are functionally independent and physically separated from the others during normal bus alignments. An alternate feed from EPSS division 2 to division 1 (first divisional pair) provides the normal and standby source of power to required safety-related systems, safety-related support systems, or components that do not have the required redundancy when certain electrical components, including the division 1 emergency diesel generator (EDG), are out of service. A similar alternate feed provides power to EPSS division 2 from division 1 when certain electrical components, including the division 2 EDG, are out of service. Similar alternate feeds exist between divisions 3 and 4 (second divisional pair).

The divisional-pair functional independence and physical separation are in accordance with IEEE Std 603-1998 for safety-related system independence. Independence and separation are assured via the separation of safety-related components between divisional pairs. A single failure or internal hazard, or both, in one divisional pair can only affect that one divisional pair. Therefore, during design-basis accidents coincident with a single failure to any electrical component in a divisional pair, the second divisional pair supports safety-related function completion in accordance with the single-failure criteria of IEEE Std 379-2000, as endorsed by RG 1.53. EPSS switchgear, load centers, MCCs, transformers, feeder breakers and load breakers are sized to provide sufficient power to start and operate connected loads, including loads fed through the alternate feeds.

The alternate feeds are capable of alignment as follows:

- Switchgear 31BDB can receive power from EDG-supported 32BDA,
- Switchgear 32BDB can receive power from EDG-supported 31BDA,
- Switchgear 33BDB can receive power from EDG-supported 34BDA, and
- Switchgear 34BDB can receive power from EDG-supported 33BDA.

Each EPSS division has an EDG as its standby power source that automatically starts and supplies the respective division if offsite power is de-energized to the division. Each EDG connects to its respective divisional bus and has no automatic connection to any other division. Large loads are sequenced onto the EPSS buses during both LOOP/LOCA and LOCA-only conditions. Loads used in LOCA mitigation are also sequenced onto the EPSS buses when they are supplied by offsite power to reduce the electrical transient on the electrical distribution system.

Two station blackout diesel generators are provided as alternate ac sources to provide power to 6.9-kV switchgear 31BDC, 32BDB, 33BDB, and 34BDC in the event of a loss of offsite power and simultaneous failure of all EDGs. The SBODGs automatically start on loss of voltage, as sensed in the NPSS, and are automatically connected to the NPSS. The EPSS switchgear is manually connected to the NPSS to receive power from the SBODGs. The NPSS and EPSS switchgear are separated by non-Class 1E breakers on the NPSS switchgear and Class 1E breakers on the EPSS switchgear. Section 9.4 describes the AAC sources and station blackout mitigation in detail.

Each EPSS division contains a low voltage regulating transformer that powers MCCs BNB02 and BNB03. The low voltage regulating transformer maintains the voltage at or above a minimum level to meet the electrical requirements of MCC loads (primarily motor-operated valves) during EPSS system voltage transients, including EDG load sequencing. The low voltage regulating transformer also provides a regulated bypass power source to the Class 1E uninterruptible power supply (EUPS) system inverter static switch. The low voltage regulating transformers are load tested to their rated power outputs during verification of the nominal output voltages listed in Table 9-1.

MCCs can contain single-phase and three-phase dry-type distribution transformers that provide power to panel boards as necessary for low voltage loads.

The EPSS provides power to certain nonsafety-related equipment connected to the EPSS buses. Isolation of nonsafety-related components to prevent Class 1E system degradation is in accordance with IEEE Std 308-2001.

#### 9.3.1.2 Normal Power Supply System

The NPSS receives offsite power from the station switchyard and distributes it at the required voltages to the nonsafety-related loads. The NPSS is separate and independent of the EPSS, as shown in Figure 9-3.

Offsite power is provided to the NPSS via normal auxiliary transformers BBT01 and BBT02, each powered from the switchyard via a separate overhead line. Each NAT is a three-phase, three-winding, oil-immersed power transformer with two identically rated 13.8-kV secondary windings. The normal NPSS alignment has each NAT powering two of the four NPSS trains. In the event of an NAT failure, the affected trains are fast-transferred to the other functioning NAT with minimum voltage decay and frequency difference to limit motor torque during the transfer.

The NPSS is configured in four trains, supplying the Turbine Island (TI) plant loads, reactor coolant pump (RCP) buses in the safeguards buildings, and auxiliary loads in the radioactive waste processing building (RWB), nuclear auxiliary building (NAB) and cooling tower structure (CTS) area. The NATs are normally aligned to the NPSS buses so that in the event of a NAT failure, the affected buses are fast-transferred to the other NAT. The arrangement and sizing of the NATs permits all four NPSS trains to be powered from each NAT, allowing one NAT to be taken out of service.

Class 1E 13.8-kV switchgear buses 31BDE, 32BDE, 33BDE, and 34BDE provide power to the four RCPs. Each switchgear is located in its respective safeguard building in the Nuclear Island (NI). The RCP supply buses are supplied from non-Class 1E buses 31BBC, 32BBC, 33BBC and 34BBC, respectively. Each RCP is powered from a different train.

The incoming feeder breakers for 13.8-kV switchgear buses 31BDE, 32BDE, 33BDE, and 34BDE (RCP supply buses) and the RCP circuit breakers are Class 1E components due to the safety-related RCP trip function. Each RCP circuit breaker trip is initiated from the associated division of the protection system (PS). If the RCP fails to trip, as monitored by current transformers, the PS will trip the respective bus supply breaker to de-energize the RCP. The RCP circuit breaker and bus supply breaker trips are generated from different PS divisions to satisfy RCP trip function single-failure criteria.

Two SBODGs provide power to NPSS switchgear buses 31BBH and 32BBH, as shown in Figure 9-3, during a LOOP. SBODG start logic and operation are described in Section 9.4. In addition to providing AAC sources for SBO mitigation, the SBODGs provide power to important nonsafety-related loads, including the non-Class 1E uninterruptible power supply system and the 12-hour uninterruptible power supply system battery chargers.

#### 9.3.1.3 Undervoltage and Degraded-Voltage Protection

The EPSS bus undervoltage and degraded-voltage monitoring and protection schemes are designed in accordance with IEEE Std 741-1997 and BTP 8-6. The undervoltage and degraded-voltage actions for a particular bus are independent of those for the redundant buses.

The EPSS undervoltage scheme is used to detect separately a loss of voltage or degraded voltage on each of Class 1E 6.9-kV buses 31BDA, 32BDA, 33BDA, and 34BDA. At each bus, all three phases are monitored to develop respective voltage signals that are sent to the PS. The PS uses a two-out-of-three logic (which prevents a fault in a single sensing circuit from initiating the system or preventing its operation) to initiate the following protective features:

- Once the loss-of-voltage setpoint is reached and a time delay is satisfied, the PS initiates a signal to separate the respective division switchgear from the preferred power supply and initiates an EDG start signal and subsequent EDG connection to the respective switchgear. The undervoltage setpoint and time delay setting in the initiation signal permits the ride-through of momentary voltage transients to prevent unnecessary separation of the offsite power supply and EDG starts.

- Once the degraded-voltage setpoint is reached, two time delays are started in the PS. The first time delay is sufficient to allow bus voltage to recover from the largest motor starting inrush current and to allow a fault to clear. If the degraded-voltage condition exists at the end of the first time delay, an alarm will alert the operator to the condition so that corrective action can be taken. The second time delay is sufficient to allow bus voltage to be restored by the EAT on-load tap changer. If a safety injection (SI) signal is received following the first time delay, the PS initiates a signal to separate the Class 1E switchgear from the preferred power source and to start the respective division EDG. If the degraded-voltage condition still exists at the completion of the second time delay, the PS separates the switchgear from the preferred power source, starts the respective division EDG, and connects the EDG to the switchgear regardless of SI signal condition.

- Large horsepower motors are tripped (shed from the bus); motors are then restarted in the appropriate sequence. The sequencing of loads onto an EPSS bus following a loss of voltage is shown in Table 9-2 for EPSS division 1 (similar to that of other divisions).

- An alarm is initiated for a degraded-voltage condition related to bus high voltage.

The NPSS undervoltage scheme is used to detect separately a loss of voltage on each of non-Class 1E 13.8-kV buses 31BBA, 32BBA, 33BBA, and 34BBA. At each bus, all three phases are monitored to develop respective voltage signals. Voltage on NAT secondary windings is also monitored to verify that there is an adequate transfer source available. Two-out-of-three logic (which prevents a single phase fault from initiating the system or preventing its operation) is used to initiate protective features as follows:

- Once the loss-of-voltage setpoint is reached and a time delay is satisfied, the respective bus load feeder breakers are tripped. The NAT secondary winding voltage monitoring verifies that there is voltage on the NAT secondary and initiates a transfer of the bus to the alternate source. The undervoltage setpoint and time delay setting permit ride-through of momentary voltage transients to prevent unnecessary bus transfers.

- An alarm is initiated for a degraded-voltage condition related to high voltages.

#### 9.3.1.4 Standby AC Emergency Diesel Generators

Four safety-related EDGs provide standby ac power to the station safety-related and select nonsafety-related loads in the event of offsite power loss or degradation. Each EDG is assigned to its respective EPSS division.

The four EDGs are located in two emergency power generating buildings (EPGBs). Each EPGB is separated into two sections, one for each EDG. The division 1 and 2 EDGs are located in the same EPGB, and the division 3 and 4 EDGs are located in the other EPGB. The two EPGBs are located on opposite sides of the safeguard buildings; this arrangement provides physical separation and protection against external hazards. Each building is a Seismic Category I structure, built to provide physical protection for the EDGs. Within each structure, the two EDGs and their support systems are physically separated by a reinforced concrete wall to protect against internal hazards.

Each EDG is provided with the support subsystems described below for reliable starting, loading, and operation to satisfy safety-related functions during design-basis accidents. Safety-related portions of each subsystem are designed and constructed in accordance with Quality Group C and Seismic Category I requirements. Additionally, safety-related portions of each subsystem are also designed and tested to ASME Code Section III requirements.

- The diesel generator starting air system provides fast start capability for the diesel engine.

- The diesel generator cooling water system dissipates heat from the crankcase, cylinder heads, turbochargers, governor oil, generator bearings, combustion charge air, and lubricating oil.

- The diesel generator has an air intake and exhaust system and a fuel oil storage and transfer system.

- The diesel generator lubrication system stores and supplies clean lubricating oil to the engine bearings, crankshaft, turbocharger, and other moving parts of the engine.

- Ambient temperature conditions are maintained for each EDG by the EPGB ventilation system. Each division has its own independent heating, ventilation, and air conditioning (HVAC) system.

Each of the four emergency generators is a Class 1E, Seismic Category I, ac synchronous, brushless three-phase generator that is a self-ventilated, air-cooled, totally enclosed unit designed to provide a nominal output voltage and frequency of 6.9 kV and 60 Hz. Each EDG also includes (phase and neutral) instrument transformers, protective relaying, an excitation system with digital voltage regulator, and controls and instrumentation for operation. The generator is designed to the standards of NEMA MG 1-2006.

The generator ratings are consistent with the load requirements identified in Table 9-2 (provided for division 1 as typical of all divisions). The voltage regulator and excitation system provide response and operating characteristics to meet RG 1.9 for load step changes and full-load operation. The generator output voltage setpoint automatically returns to rated voltage when the EDG is shut down or upon switchover to emergency mode.

During normal plant operation, the EDGs remain in standby mode, with the engines prelubricated and their cooling water preheated so that they are ready to start and accept loads. The PS EDG start signal is based on EPSS bus voltage, as described in the previous section, or an SI signal.

Each EDG is designed to start and accelerate to rated speed, and then to carry the loads listed in Table 9-2 in the sequence indicated. The EDG capacity can supply the power requirements of the safety-related and nonsafety-related loads assigned to the associated EDG bus, as well as the loads of an additional division that could be aligned to the EDG via an EPSS alternate feed.

If an LOOP occurs during EDG testing, the associated EPSS bus separates from the offsite power supply. The other redundant divisional EPSS buses separate from the EATs due to their individual bus monitoring circuits and undervoltage protection. The remaining EDGs start and supply power to their respective EPSS divisions.

Once an EDG start signal is initiated, the EDG automatically starts and accelerates to rated speed, adjusts for proper speed and voltage, and attains a ready-to-load condition. The startup time of an unloaded diesel unit, from the emergency start signal to the attainment of nominal speed, rated generator frequency, and rated voltage, is less than or equal to 15 seconds. When the EDG output breaker permissives of EDG speed, voltage, and respective BDA switchgear normal and alternate source breakers being open are met, the EDG output breaker closes. Closure of the EDG output circuit breaker and load sequencing is performed by the PS. The PS controls EDG load sequencing by controlling the placement of loads onto the respective EPSS buses at programmed time intervals. Load shedding is accomplished by individually tripping large horsepower motors that were operating prior to the undervoltage condition. Motors that were shed are then restarted in the appropriate sequence or available for manual start as directed by operating procedures.

Synchronization circuitry and indicators allow synchronization of the EDG to the offsite source following the restoration of offsite power. The synchronization capability allows for shifting loads back to the preferred power source and restoring the EPSS supply to the EATs. The EDGs are then shut down and returned to a standby condition.

### 9.3.2 DC Power Systems

The dc power system includes the Class 1E uninterruptible power supply system (EUPS), the non-Class 1E 12-hour uninterruptible power supply system (12UPS), and the non-Class 1E uninterruptible power supply system (NUPS). In general, the EUPS provides uninterruptible dc control power for safety-related switchgear, load centers, and instrumentation and control systems, and uninterruptible ac motive power for safety-related motor-operated valves. The 12UPS provides uninterruptible dc control power and ac motive power for similar nonsafety-related equipment during normal operation and for selected equipment for at least 12 hours. The NUPS provides uninterruptible dc control power and ac motive power for various nonsafety-related balance-of-plant components.

#### 9.3.2.1 Class 1E Uninterruptible Power Supply System

The EUPS components are located in Seismic Category I buildings in areas absent of high energy lines. Separation between redundant EUPS divisions is provided by the Seismic Category I buildings. EUPS components are located so that there is physical separation between Class 1E equipment and non-Class 1E equipment. The separation also prevents an internal hazard from resulting in a redundant system common-mode failure. EUPS Class 1E batteries, battery chargers, inverters, MCCs, and other components meet the RG 1.29 Seismic Category I guidelines.

Each EUPS division contains a Class 1E 250-Vdc two-hour-rated battery, two 100%-capacity battery chargers, an inverter with a static bypass switch, distribution equipment, and multiple ac/dc and dc/dc converters to supply 480 Vac, 250 Vdc, 120 Vac, and 24 Vdc to the respective EUPS loads. The nominal ratings of each major system component are listed in Table 9-3. The EUPS is illustrated in Figure 9-2.

When an alternate feed is in service, the connected EUPS battery charger is aligned to the respective division BMB load center, which provides an EDG-backed power source to the battery charger. Proper alignment of the battery charger during implementation of an alternate feed and separation of safety-related components between divisional pairs provides EUPS independence and physical separation in accordance with IEEE Std 603-1998 for safety system independence.

The EUPS also provides power to the radiation monitoring system (which provides some Type E post-accident monitoring variables), applicable communications systems, and the special emergency lighting system. Separation is provided between these non-Class 1E circuits and Class 1E circuits in accordance with IEEE Std 384-1992.

The EUPS supplies assigned loads during normal and off-normal operation, including when onsite ac power is not available and during the starting phase of the EDGs, when the battery charger ac input power is lost. During a loss of power to a division's battery chargers, the EUPS loads are powered from the battery via the dc distribution switchboard or inverters until a battery charger has been repowered from the EDG. Both battery chargers in each of divisions 1 and 4 are capable of being supplied by an SBODG. The battery chargers supplied from load centers 32BMB and 33BMB in divisions 2 and 3, respectively, are also capable of being powered from the SBODGs.

Local battery charger and inverter indications permit system monitoring. DC switchboard and 480-Vac MCC voltage, battery charger output current, and battery charge or discharge rate are indicated in the MCR and at the remote shutdown station (RSS). A dc switchboard undervoltage alarm indicates that the battery is being discharged, and a dc system ground alarm is provided in the MCR.

**250-VDC Batteries**

The EUPS battery cells are the vented (flooded) lead-acid type. Each battery is immediately available during normal operation and following the loss of power from the ac power system. Each battery is able to provide power for starting and operating design-basis-event (DBE) loads for a minimum of two hours when the ac supply to the associated battery chargers is lost. The battery voltage profile during the first two hours of discharge provides satisfactory operation of safety-related electrical loads during postulated DBE conditions.

Each EUPS divisional battery is located in a ventilated battery room that is separated from other EUPS equipment. The electrical division of the safeguard building ventilation system (SBVS) prevents accumulation of hydrogen and maintains design battery temperature. Hydrogen buildup is limited to one percent of the total volume of the battery area in accordance with RG 1.128.

The EUPS battery installation design is in accordance with IEEE Std 484-2002, as augmented by RG 1.128. The EUPS batteries are qualified in accordance with IEEE Std 535-1986, as endorsed by RG 1.158.

The dc portion of the EUPS is operated as an ungrounded system.

**250-VDC Battery Chargers**

Each EUPS division contains two 100%-capacity battery chargers that are powered from their respective division EDG-backed Class 1E load centers and MCCs. Each in-service battery charger provides power for steady-state operation of connected loads during normal or post-accident operation while either maintaining the respective battery fully charged or recharging the battery to the fully charged state. The capacity of each battery charger is based on the largest combined demands of the various continuous steady-state loads, plus the capacity to restore the battery charge after the bounding DBE discharge to a state at which the battery can perform its design-basis function for subsequent postulated operations. The battery chargers in each division are independent of the battery chargers in the other redundant divisions.

The battery chargers are normally operated in a float-charge mode to maintain their associated battery fully charged. The battery charger operation can be selected between the float-charge mode and the equalize-charge mode. The output of the charger is adjustable in each mode of operation. The battery chargers are designed to prevent their ac power supplies from becoming loads batteries. Transients from the ac system are prevented from unacceptably affecting the dc system, and vice versa. A current limiting device automatically responds to limit the charger output current to prevent charger damage in an overload condition. The battery charger output is filtered to reduce output ripple current over the entire load range of the charger.

These battery charger parameters are alarmed in the MCR to alert operators to abnormal conditions:

- Battery charger output breaker open,
- Battery charger dc output failure as determined by low charger output current,
- Battery charger ac power failure, and
- Battery charger low dc voltage.

Each charger is capable of being isolated from the ac and dc systems by means of a disconnecting device to place the battery charger in standby condition or to isolate it for maintenance. During normal operation, one battery charger in each division is in service, with the other charger in standby. In the event of a charger failure, the other charger is placed in service manually at the local charger cabinet. The battery chargers incorporate an interlock in their output breakers to prevent having two different divisional power sources supplying power to the same bus simultaneously.

AC distribution system faults or battery charger internal faults are prevented from affecting the inverter-powered loads. The battery charger high voltage shutdown relay removes the battery charger from service before the inverter output is affected. Following a trip of battery charger output, the inverter continues to supply the MCC loads, including the power source to the instrumentation and control cabinets.

**480-VAC Inverters**

Four Class 1E inverters provide nominal 480-Vac, three-phase, 60-Hz power to the four independent 480-Vac vital ac distribution MCCs (31BRA, 32BRA, 33BRA, and 34BRA), one per division. Each inverter is normally powered from its respective dc distribution bus (31BUC, 32BUC, 33BUC, or 34BUC).

Each inverter includes a static bypass switch to transfer power from the inverter to the EDG-backed bypass source. The static bypass switch automatically transfers to the bypass source on inverter failure, inverter overload, or inverter output undervoltage or overvoltage. The bypass source can also be selected manually. The transfer is a make-before-break transfer to the respective division voltage-regulated MCC (31BNB02, 32BNB02, 33BNB02, or 34BNB02), which occurs with minimal change in voltage, frequency, or phase displacement. Transfer to the bypass source is only possible when the bypass source is available. During inverter maintenance and tests, the vital ac distribution MCC supply is provided directly from the bypass source.

**24-VDC Converters**

Each EUPS division supplies the respective division Class 1E instrumentation and control (I&C) equipment with 24 Vdc via both 480-Vac-to-24-Vdc converters and 250-Vdc-to-24-Vdc converters. Typical converter cubicle connections to the I&C system are shown in Figure 9-2. The converter cubicles are operated in parallel to provide two power supply feeds to each specific I&C cabinet group. Both the ac/dc and dc/dc converters are sized to supply the entire I&C cabinet group so that on failure of one converter cubicle, the other converter cubicle can supply the power demand of the entire I&C cabinet group.

A division’s 480-Vac-to-24-Vdc converter cubicles contain several converter modules in parallel, supplied from the inverter-fed MCC, to provide an uninterruptible normal supply. The 250-Vdc-to-24-Vdc converter cubicles also contain several converter modules in parallel, supplied from the battery switchboard, to provide an alternate power supply to the I&C systems. The output of each converter module has a fuse or circuit breaker installed for individual component protection. Electrical isolation between the converter cubicles is provided by blocking diodes.

Normally the ac/dc and dc/dc converter module sets are located in separate converter cubicles. For I&C cabinet groups with low power requirements, the ac/dc and dc/dc converter module sets are located in the same cabinet. The ac/dc and dc/dc converter module sets can also be installed directly inside the I&C cabinet that they supply. The converter cubicles are located near the I&C cabinet groups which they supply in the respective safeguard buildings and emergency power generating buildings.

**Uninterruptible Motor Control Centers and Panel Boards**

MCCs 31BRA, 32BRA, 33BRA, and 34BRA distribute the respective inverter outputs to the safety-related loads, including the ac/dc converter feeds, and select nonsafety-related loads. Panel boards 31BGA01, 32BGA01, 33BGA01, and 34BGA01 provide 120-Vac uninterruptible single-phase power supplies and overcurrent protection for safety-related loads. Panel boards 31BLB01, 32BLB01, 33BLB01, and 34BLB01 provide 120-Vac uninterruptible single-phase power and overcurrent protection for selected nonsafety-related loads. The panel boards are supplied with uninterruptible power from the respective division BRA MCCs.

### 9.3.2.2 12-Hour Uninterruptible Power Supply System

The 12UPS is a non-Class 1E system that supplies uninterruptible ac and dc power to nonsafety-related loads in the safeguard buildings. In addition to these loads, the 12UPS supplies SBODG auxiliary loads and control power for circuit breakers used to align the SBODGs to the NPSS and EPSS.

The 12UPS system, as shown in Figure 9-4, is comprised of two separate trains supported by separate dc battery systems. Each train consists of a 250-Vdc non-Class 1E battery, a 100%-capacity battery charger, an inverter with a static bypass switch, 250-Vdc distribution switchboards, 480-Vac MCCs, and ac/dc and dc/dc converters. A single standby charger is available to be placed in service manually should the normal charger in either train fail or require maintenance that necessitates its removal from service. The 12UPS batteries, battery chargers, inverters, certain MCCs (31BRC and 32BRC), and certain dc switchboards (31BUD and 32BUD) are located in separate dedicated electrical rooms in the switchgear building. Other MCCs (31BRB, 32BRB, 33BRB, and 34BRB) and other dc switchboards (31BUE, 32BUE, 33BUE, and 34BUE) are located in the respective division safeguard buildings.

Each 12UPS battery has adequate capacity for starting and operating connected loads for a minimum of two hours during an LOOP. Following the initial two hours, certain loads must be manually disconnected so that the system has adequate capacity to complete its 12-hour, beyond-design-basis, severe-accident mission if required. During the entire 12-hour discharge time, assuming that the loads are properly shed, the battery voltage does not drop below the minimum values required for the severe-accident loads.

Each 12UPS battery charger supplies the normally operating assigned loads while maintaining the battery fully charged or recharging the battery following battery discharge. The standby battery charger has the same capacity as that of the normal battery chargers. The time to recharge the battery from a discharged state to approximately 95% capacity during operating conditions is 24 hours.

Each inverter is equipped with a static bypass switch to provide power from the bypass source in case of inverter failure, or high or low input voltage or output voltage.

The 12UPS provides power to nonsafety-related I&C cabinets located in the safeguard buildings from 480-Vac MCCs and 250-Vdc switchboards through ac/dc and dc/dc converters, respectively. The converter cubicles are designed and operated similar to those for the EUPS converters described above.

NPSS trains 1 and 2 provide the normal power to the 12UPS battery chargers from load centers 31BFX and 32BFX, respectively. If voltage is lost on NPSS 6.9-kV switchgear 31BBH or 32BBH, the associated SBODG automatically starts and re-powers its associated bus. Since these switchgear supply load centers 31BFX and 32BFX, the SBODGs provide a standby source of power to the battery chargers.

The 12UPS components are equipped with local and remote indications and alarms that provide operators with accurate system status. The following 12UPS indications are provided in the MCR:

- The inverter-supplied MCC bus voltages,
- The inverter common trouble alarm,
- The dc system ground alarm,
- The dc distribution bus voltages, and

- The charger common trouble alarm.

The 12UPS does not perform any safety-related functions. The 12UPS provides electrical power for beyond-design-basis events (e.g., severe accident and SBO). The following severe-accident loads are powered from MCCs 31BRB, 32BRB, 33BRB, and 34BRB:

- The ac/dc and dc/dc converters for control and monitoring systems,
- Dedicated valves for primary depressurization for each primary depressurization system line,
- Outer containment isolation valves (aligned to the 12UPS during a severe accident), and
- Illumination of monitoring displays in the MCR.

The 12UPS is separated from the EPSS by two normally open and manually operated breakers.

#### 9.3.2.3 Non-Class 1E Uninterruptible Power Supply System

The NUPS provides uninterruptible ac and dc power to nonsafety-related loads that are needed to remain operational for investment protection, such as turbine-generator protection and lube oil pumps.

The NUPS, as shown in Figure 9-5, is comprised of two separate trains supported by separate battery systems. Each train consists of a 250-Vdc non-Class 1E battery, a 100%-capacity battery charger, 250-Vdc distribution switchgear, ac/dc converters, dc/dc converters, a 480-Vac MCC, and an inverter with a static bypass switch. A single standby charger is available to be placed in service manually should either in-service charger fail or require maintenance that necessitates its removal from service. The NUPS components are located in separate dedicated electrical rooms in the switchgear building.

Each NUPS battery has sufficient capacity for starting and operating required loads for a minimum of two hours, should the battery charger lose ac input power. During the discharge time, the voltage of the battery does not drop below the minimum values required for the loads.

Each NUPS battery charger powers the normally operating assigned loads while maintaining the battery fully charged or recharging the battery following battery discharge. The standby battery charger has the same capacity as that of the normal battery chargers. Each inverter is equipped with a static bypass switch to provide power from the bypass source in case of inverter failure.

NPSS trains 1 and 2 provide the normal power to the NUPS battery chargers from load centers 31BFX and 32BFX, respectively. If voltage is lost on NPSS 6.9-kV switchgear 31BBH or 32BBH, the associated SBODG automatically starts and re-powers its associated bus. Since these switchgear supply load centers 31BFX and 32BFX, the SBODGs provide a standby source of power to the battery chargers.

The NUPS components are equipped with indications and alarms that provide operators with system status. The following NUPS indications are provided in the MCR:

- The inverter common trouble alarm,
- The NUPS system ground alarm, and
- The charger common trouble alarm.

The NUPS distributes power from 250-Vdc switchboards 31BUM and 32BUM to the control rod drive control system for motive power to the control rod drive mechanism (CRDM) operating coils. Power to the CRDM coils is supplied through two sets of in-series reactor trip breakers located in separate cabinets within CRDM distribution panels 32BUB and 33BUB in safeguard buildings 2 and 3, respectively. The reactor trip breakers and the distribution panels are Class 1E devices; the breakers satisfy the safety-related function of tripping open to insert the reactor control rods when the PS de-energizes the reactor trip breaker undervoltage coils. Trip breaker position is indicated in the MCR and RSS. The diverse actuation subsystem described in Chapter 8.0 actuates the reactor trip breaker shunt trip coils to mitigate anticipated-transient-without-scram conditions.

## 9.4 Station Blackout

### 9.4.1 Station Blackout Coping Analysis

The SBO rule of 10 CFR 50.63 requires each plant to specify an SBO coping duration based on the redundancy of onsite emergency ac power sources, the reliability of the onsite emergency ac power sources, the expected frequency of LOOPs, and the probable time needed to restore offsite power. Based on (1) conservatively selected site-specific offsite power supply characteristics; (2) four redundant and independent Class 1E EDGs, with only one required for decay heat removal; and (3) an EDG targeted reliability of 0.95 (all factors considered in accordance with RG 1.155 methodology); the US-EPR’s worst-case SBO coping duration is eight hours.

10 CFR 50.63 further requires that the capability for coping with an SBO for the determined duration shall be determined by an appropriate coping analysis. Since the provision of alternate ac (AAC) sources constitutes an acceptable capability to withstand an SBO in accordance with 10 CFR 50.63(c)(2), two non-Class 1E SBODGs are provided as AAC sources. Because the US-EPR’s AAC sources meet the capacity and capability requirements of 10 CFR 50.63(c)(2) and can be demonstrated to be available to power shutdown buses within 10 minutes of the onset of an SBO, no coping analysis for withstanding an SBO is required for the US-EPR design.

During normal plant operation, each SBODG is in standby with the diesel engine ready to be started. Each diesel engine is prelubricated, and its cooling water is preheated. At the start of an SBO, the two-hour-rated EUPS batteries supply dc power to the EUPS inverters and their critical loads, including I&C power and dc control power. Safe-shutdown loads are not connected to the SBODG buses. On a loss of voltage to the 6.9-kV switchgear, Class 1E loads are automatically stripped from their respective buses. Non-Class 1E loads are stripped from each SBODG-supplied bus to the extent that the remaining load is less than the SBODG rating for immediately connected loads (typically 25 to 30 percent of the machine's continuous load rating). An automatic start signal is issued to the SBODGs. Each SBODG output breaker automatically closes onto its associated non-Class 1E bus upon reaching its nominal frequency and voltage. Safe-shutdown loads may be manually added within ten minutes from the start of the event.

As required by RG 1.155 for AAC power sources selected specifically for satisfying the requirements for SBO, the US-EPR design meets the following criteria:

- The AAC power sources are not normally directly connected to the preferred or blacked-out unit onsite emergency power system. The SBODGs are normally not running. Two breakers exist between each SBODG and the nearest Class 1E bus.

- There is a minimum potential for common-cause failure with the preferred or blacked-out unit onsite emergency ac power sources. No single-point vulnerability exists whereby a weather-related event or single active failure could disable any portion of the blacked-out unit's onsite sources and simultaneously fail the AAC power sources. Common-cause failure is also avoided by specifying and selecting AAC source equipment, including the engine, generator, and primary support equipment, that is different from the corresponding EDG equipment.

- Including the time required to prepare the SBODG buses, the AAC power sources can be connected to their associated EPSS buses within ten minutes after the onset of an SBO. When an SBO condition occurs, load and source breakers will be opened on each SBODG bus, as required to separate the SBODG from other power sources, and to reduce the immediately connected (non-Class 1E) load to less than the machine's rating (typically 25 to 30 percent of the machine's continuous rating). The SBODGs then start automatically. If the SBODGs fail to start automatically, they can be manually started from the MCR. One AAC power source is capable of manual connection to the division 1 and division 2 safety buses. The other AAC power source is capable of manual connection to the division 3 and division 4 safety buses. After the generators are connected to their respective Class 1E 6.9-kV buses, safe-shutdown loads are added manually.

- The AAC power sources have sufficient capacity to operate the systems necessary for coping with an SBO for the time required to bring the plant to and maintain it in a safe-shutdown condition. Fuel consumption is within the transfer capability of the fuel oil system. The minimum maintained fuel supply is sufficient to permit operation at the machines' continuous rating for the SBO coping duration noted above.

- The AAC power sources conform to the diversity guidance provided by RG 1.155, Appendix B, with reference to RG 1.155 Regulatory Position 3.3.5.

### 9.4.2 Station Blackout Diesel Generators

Two separate and independent nonsafety-related station blackout diesel generators are provided to mitigate a postulated SBO. The SBODGs have the capacity and capability to bring the plant to and maintain it in a nondesign-basis-accident (non-DBA) safe-shutdown condition without any support systems powered from the preferred power supply (offsite grid) or from the EPSS. Accomplishing a (non-DBA) safe shutdown means bringing the plant to those shutdown conditions specified in the US-EPR technical specifications as “hot standby.”

The SBODGs are located in separate areas of the switchgear building. The SBODGs do not share control power; heating, ventilation, and air conditioning (HVAC); engine cooling; or fuel systems with the EDGs. There are no weather-related events or single active failures that can disable the SBODGs and EDGs simultaneously.

The major system loads to which the SBODGs provide power during SBO conditions are:

- The division 1 and division 4 emergency feedwater (EFW) pumps,
- HVAC systems to maintain MCR habitability and SBO equipment environments,
- Selected I&C systems,
- MCR lighting, and
- Main steam relief trains.

A summary of the loads supported by an SBODG is given in Table 9-4 (for Train 1 only as an example).

To minimize the potential for common-cause failure with the onsite emergency ac power sources, the SBODGs are of a different model than the EDGs. Each SBODG is a self-contained unit (including auxiliaries) that is independent of the plant’s preferred and emergency power sources. The dc power system is electrically independent from the preferred and Class 1E power systems. The dc power system is of sufficient capability and capacity for operation of the dc loads associated with the AAC sources for the maximum necessary SBO duration. Prior to an SBO, none of the SBODGs and EDGs share emergency buses or loads, auxiliary services, or control circuitry. The SBODG radiators are cooled by forced air provided by fans powered from the SBODG-supplied buses, whereas the EDG heat exchangers are cooled by an external cooling water system. The switchgear building is divided so that each SBODG is physically separated from the other. The SBODGs and EDGs and their associated circuitry and auxiliary systems are physically, electrically, and mechanically separated.

Figures 9-1 and 9-3 illustrate the connections for the distribution of power from the SBODGs to the EPSS. The SBODGs are aligned with the plant buses as follows:

- SBODG XKA50 connects to NPSS bus 31BBH, which can be connected to EPSS buses 31BDC and 32BDB.

- SBODG XKA80 connects to NPSS bus 32BBH, which can be connected to EPSS buses 34BDC and 33BDB.

Each SBODG is provided with the following support subsystems:

- The diesel engine starting air system provides compressed air to rotate each engine until combustion begins and the engine accelerates under its own power. The starting air system includes ac-driven air compressor(s), compressed air receivers, air filters, air dryers, monitoring equipment, piping, and valves. Each SBODG has a separate, independent starting air system. Starting at their low pressure alarm setpoint, the air receivers can crank a cold diesel engine five times without recharging.

- The diesel engine fuel oil storage and transfer system stores adequate and acceptable fuel oil to meet the mission time for the specified SBO coping duration, at full-load operation, including allowances for fuel consumed during routine testing, unusable tank volumes, and measurement uncertainty. Each SBODG has a separate, independent fuel oil storage and transfer system. The system includes a storage tank, electrically driven transfer pump(s), a day tank, a fuel delivery pump, a fuel injection pump, piping, filter(s), and a monitoring system. Fuel storage for each SBODG is located in its respective building. The day tank elevation for each SBODG provides a slight positive pressure for the engine-driven fuel pump(s). The fuel oil storage tank can be refilled without interrupting diesel operation.

- The diesel engine lubricating oil system stores clean lubricating oil and supplies it as needed for the SBODG engine bearings, crankshafts, turbocharger, and other moving engine parts. Each SBODG has its own lube oil system. Lube oil may be added when the engine is in standby or when the engine is operating. When the engine is in standby, a pump circulates lube oil through a heater. The lube oil storage capacity in the engine sump supports the mission time for the specified SBO coping duration.

- The diesel engine cooling system dissipates heat from the crankcases, cylinder heads, and lubricating oil. The system has an engine-driven cooling water pump, air/water radiator(s) with fan(s), a coolant preheater, a preheating circulation pump, a temperature regulating valve, and an expansion tank. Engine cooling water is continuously heated when the engines are in standby. Temperature indicators and alarms are provided.

- Each SBODG has its own combustion air system, which supplies filtered outside air to the diesel engine for combustion. Air intake filters remove atmospheric contaminants from the incoming air. Air filters are equipped with differential pressure indicators to monitor for fouling and to indicate the need to change filters.

- Each SBODG has its own exhaust system, which collects exhaust gas from the cylinders and transfers it to the environment through the turbocharger and the exhaust gas silencer. The exhaust lines are separated from the combustion air lines to prevent mixing, and are insulated to lower surface temperatures and to reduce the risk of fire.

Each SBODG generator is an air-cooled, synchronous three-phase machine with internal poles and an external exciter. The nominal output voltage and frequency are 6.9 kV and 60 Hz. A fan mounted on the generator shaft provides cooling air from the diesel room. The excitation system consists of a pilot exciter, a three-phase ac exciter, a voltage regulator, and instrumentation transformers and transducers. A permanent magnet generator provides power to a voltage regulator, which in turn supplies regulated power to the generator exciter for control of the generator output voltage.

The SBODGs have the following I&C and grounding features:

- Each SBODG includes generator (phase and neutral) instrumentation transformers, generator protective relaying, and generator excitation system controls and instrumentation.

- The SBODG instrumentation and controls are provided by I&C systems powered from the 12UPS.

- Grounding for personnel protection and generator neutral grounding are consistent with the overall plant grounding requirements.

Each SBODG and its power distribution equipment are sized to provide the voltage and frequency needed for proper operation of their connected loads. The highest expected continuous loading has been calculated using conservative estimates of load characteristics. Uncertainties associated with SBODG loading are addressed by maintaining a margin of at least five percent.

## Table 9-1 Onsite AC Power System Component Data Nominal Values
Sheet 1 of 2

| Component | | Nominal Ratings |
|---|---|---|
| 1. | MSUs<br>(30BAT01, 30BAT02,<br>30BAT03, 30BAT04) | 26 kV-(site-specific), single phase, 60 Hz<br>2100MVA (700MVA each phase)<br>Cooling Class ODAF<br>Temperature Rise 65°C |
| 2. | EATs (30BDT01, 30BDT02) | (site-specific)-6.9 kV-6.9 kV, three phase, 60 Hz<br>Rated Power 25/33.3/41.5 MVA<br>Cooling Class ONAN/ONAF/ONAF<br>Temperature Rise 65°C |
| 3. | NATs (30BBT01, 30BBT02) | (site-specific)-13.8 kV-13.8 kV, three phase, 60 Hz<br>Rated Power 140/186.2/232.4 MVA<br>Cooling Class ONAN/ONAF/ONAF<br>Temperature Rise 65°C |
| 4. | NPSS 13.8 kV Switchgear | Rated Maximum Voltage, 15 kV<br>Maximum Continuous Current, 3000 A<br>Maximum Bus Bracing Current, 160 kA rms |
| | NPSS 13.8 kV Feeder Breaker | Rate Maximum Voltage, 15 kV<br>Maximum Continuous Current, 3000 A<br>Maximum Rated Interrupting Current, 63 kA<br>Maximum Rated Closing and Latching Current 164 kA (peak value) |
| 5. | EPSS and NPSS 6.9 kV Switchgear | Rated Maximum Voltage, 8.25 kV<br>Maximum Continuous Current, 2000 A<br>Maximum Bus Bracing Current, 104 kA rms |
| | EPSS and NPSS 6.9 kV Feeder Breaker | Rated Maximum Voltage, 8.25 kV<br>Maximum Continuous Current, 2000 A<br>Maximum Rated Interrupting Current 40 kA rms<br>Maximum Rated Closing and Latching Current 104 kA (peak value) |
| 6. | EPSS and NPSS 480 Vac Load Centers | Rated Maximum Voltage, 508 V<br>Maximum Continuous Current, 4000 A<br>Maximum Bus Bracing Current, 100 kA rms |
| | EPSS and NPSS 480 Vac Feeder Breaker | Rated Maximum Voltage, 508 V<br>Maximum Continuous Current, 4000 A<br>Maximum Rated Interrupting Current 100 kA rms |

## Table 9-1 Onsite AC Power System Component Data Nominal Values
Sheet 2 of 2

| Component | | Nominal Ratings |
|---|---|---|
| 7. | EPSS 480 Vac MCCs | Rated Maximum Voltage, 508 V<br>Maximum Continuous Current, 1600 A<br>Maximum Bus Bracing Current, 100 kA rms |
| | NPSS 480 Vac MCCs | Rated Maximum Voltage, 508 V<br>Maximum Continuous Current, 3200 A<br>Maximum Bus Bracing Current, 100 kA rms |
| | EPSS 480 Vac MCC Feeder Breaker | Rated Maximum Voltage, 508 V<br>Maximum Continuous Current, 1600 A<br>Maximum Bus Bracing Current, 100 kA rms |
| | NPSS 480 Vac MCC Feeder Breaker | Rated Maximum Voltage, 508 V<br>Maximum Continuous Current, 3200 A<br>Maximum Bus Bracing Current, 100 kA rms |
| 8. | EPSS Distribution Transformers: | Dry type<br>60 Hz, three phase, air cooled |
| | 31BMT01, 32BMT01, 33BMT01, 34BMT01, 31BMT02, 34BMT02 | 6.9 kV to 480 Vac<br>2500 kVA |
| | 32BMT02, 33BMT02, 31BMT04, 32BMT04, 33BMT04, 34BMT04, 32BMT03, 33BMT03 | 6.9 kV to 480 Vac<br>1500 kVA |
| | 31BNT01, 32BNT01, 33BNT01, 34BNT01 | 480 Vac to 480 Vac<br>500 kVA<br>Rated Input Voltage 460 Vac<br>Rated Output Voltage 480 Vac |

**Table 9-2 Division 1 Emergency Diesel Generator Nominal Loads**
**Sheet 1 of 6**

| Time Seq. (s) [13] | Load Description [8] [15] [19] | Volts | Rating (hp/kW) [3] | Alternate Feed Load (kW) [1] [12] | Operating Load LOOP (kW) [1] [12] | Operating Load DBA/ LOOP (kW) [1] [12] |
|---|---|---|---|---|---|---|
| Load Step Group 1 | | | | | | |
| 0 | Start Signal | | | | | |
| 15 | EDG reaches rated speed and voltage/output breaker closes | | | | | |
| 15 | Emergency power generating building electric room chiller unit | 480 | 18.5 kW | | 18.5 | 18.5 |
| 15 | Emergency power generating building electric room supply fan | 480 | 10 Bhp | | 8.3 | 8.3 |
| 15 | Emergency power generating building fuel oil storage tank room fan | 480 | 13.4 Bhp | | 11.1 | 11.1 |
| 15 | EDG starting air compressor | 480 | 61 Bhp | | 50.6 | 50.6 |
| 15 | EDG auxiliary loads | 480 | 9.7 kW | | 9.7 | 9.7 |
| 15 | Vent stack monitoring | 480 | 13 kW | | 13 | 13 |
| 15 | Division 1 EUPS battery charger [4] | 480 | 106 kW | | 106 | 106 |
| 15 | Annulus ventilation heating unit | 480 | 6 kW | | 4.2 [2] | 4.2 [2] |
| 15 | Annulus ventilation fan | 480 | 4.3 Bhp | | 3.6 | 3.6 |
| 15 | KAA/LAR valve room cooling fan | 480 | 5 Bhp | | 4.1 | 4.1 |
| 15 | Extra boration room cooling fan | 480 | 14 Bhp | | 11.6 | 11.6 |
| 15 | Fuel pool cooling punp room cooling fan | 480 | 7.75 Bhp | | 6.4 | 6.4 |
| 15 | Fuel pool cooling punp room cooling fan | 480 | 7.75 Bhp | | 6.4 | 6.4 |
| 15 | Fuel building ventilation heating unit [7] | 480 | 15 kW | | 0 | 0 |

**Table 9-2 Division 1 Emergency Diesel Generator Nominal Loads**
**Sheet 2 of 6**

| Time Seq. (s) (13) | Load Description (8) (15) (19) | Volts | Rating (hp/kW) (3) | Alternate Feed Load (kW) (1) (12) | Operating Load LOOP (kW) (1) (12) | Operating Load DBA/ LOOP (kW) (1) (12) |
|---|---|---|---|---|---|---|
| 15 | Safety chilled water pump (6) | 480 | 100 Bhp | | 82.9 | 82.9 |
| 15 | Safety chilled water pump (6) | 480 | 100 Bhp | | 82.9 | 82.9 |
| 15 | Safety chiller condenser fans | 480 | 240 kW | | 240 | 240 |
| 15 | Main control room air conditioning fan | 480 | 27 Bhp | | 22.4 | 22.4 |
| 15 | Main control room air conditioning filtration unit heater (11) | 480 | 10 kW | | | 7 (2) |
| 15 | Main control room air conditioning iodine filtration fan (11) | 480 | 10 Bhp | | | 8.3 |
| 15 | Safeguard building ventilation heaters (7) | 480 | 210 kW | | 0 | 0 |
| 15 | Safeguard building ventilation supply fan | 480 | 78 Bhp | | 64.7 | 64.7 |
| 15 | Safeguard building ventilation return fan | 480 | 43 Bhp | | 35.6 | 35.6 |
| 15 | Safeguard building battery exhaust fan | 480 | 7 Bhp | | 5.8 | 5.8 |
| 15 | Emergency feed water room ventilation recirculation fan | 480 | 2 Bhp | | 1.7 | 1.7 |
| 15 | Emergency lighting panels (18) | 480 | 165.7 kW | | 165.7 | 165.7 |
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | | 4.1 | 4.1 |
| 15 | Component cooling valve hydraulic pump | 480 | 5 Bhp | | 4.1 | 4.1 |
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | | 4.1 | 4.1 |
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | | 4.1 | 4.1 |

Table 9-2  Division 1 Emergency Diesel Generator Nominal Loads
Sheet 3 of 6

| Time Seq. (s) (13) | Load Description (8) (15) (19) | Volts | Rating (hp/kW) (3) | Alternate Feed Load (kW) (1) (12) | Operating Load LOOP (kW) (1) (12) | Operating Load DBA/ LOOP (kW) (1) (12) |
|---|---|---|---|---|---|---|
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | | 4.1 | 4.1 |
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | | 4.1 | 4.1 |
| 15 | Division 2 EUPS battery charger | 480 | 106 kW | 106 | | |
| 15 | Reactor building ventilation filtration fan | 480 | 10 Bhp | 8.3 | | |
| 15 | KAA/LAR valve room cooling fan | 480 | 5 Bhp | 4.1 | | |
| 15 | Safeguard building ventilation heaters (7) | 480 | 180 kW | 0 | | |
| 15 | Safeguard building ventilation supply fan | 480 | 72 Bhp | 59.7 | | |
| 15 | Safeguard building ventilation return fan | 480 | 43 Bhp | 35.6 | | |
| 15 | Safeguard building battery exhaust fan | 480 | 6 Bhp | 5 | | |
| 15 | Emergency feed water ventilation recirculation fan | 480 | 2 Bhp | 1.7 | | |
| 15 | KAA pump room recirculation fan | 480 | 2 Bhp | 1.7 | | |
| 15 | Emergency lighting panels (18) | 480 | 86.7 kW | 86.7 | | |
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | 4.1 | | |
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | 4.1 | | |
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | 4.1 | | |
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | 4.1 | | |

## Table 9-2 Division 1 Emergency Diesel Generator Nominal Loads
Sheet 4 of 6

| Time Seq. (s) (13) | Load Description (8) (15) (19) | Volts | Rating (hp/kW) (3) | Alternate Feed Load (kW) (1) (12) | Operating Load LOOP (kW) (1) (12) | Operating Load DBA/ LOOP (kW) (1) (12) |
|---|---|---|---|---|---|---|
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | 4.1 | | |
| 15 | Component cooling water valve hydraulic pump | 480 | 5 Bhp | 4.1 | | |
| 15 | Additional connected alternate feed loads | 480 | 73.7 kW | 73.7 | | |
| 15 | Reactor building ventilation filtration fan | 480 | 11 Bhp | | 9.1 | 9.1 |
| 15 | Reactor building filtration heating | 480 | 25 kW | | 25 | 25 |
| 15 | Reactor building pit fan | 480 | 14 Bhp | | 11.6 | 11.6 |
| 15 | Reactor building pit fan | 480 | 14 Bhp | | 11.6 | 11.6 |
| 15 | MHSI/LHSI room recirculation fan | 480 | 5 Bhp | | 4.1 | 4.1 |
| 15 | JMU/KUL sample room recirculation fan | 480 | 5 Bhp | | 4.1 | 4.1 |
| 15 | Main control room air conditioning heaters (7) | 480 | 21 kW | | 0 | 0 |
| 15 | Safeguard building controlled-area ventilation system heating unit | 480 | 21 kW | | | 14.7 (2) |
| 15 | Safeguard building controlled-area fan | 480 | 9 Bhp | | | 7.5 |
| 15 | Essential service water building ventilation and auxiliaries | 480 | 110 kW | | 85.6 (2) (12) | 85.6 (2) (12) |
| 15 | Essential service water building recirculation fan | 480 | 10 Bhp | | 8.3 | 8.3 |
| 15 | Emergency power generating building supply fan 1 | 480 | 100 hp | | 82.9 | 82.9 |
| 15 | Emergency power generating building supply fan 2 | 480 | 100 hp | | 82.9 | 82.9 |

## Table 9-2 Division 1 Emergency Diesel Generator Nominal Loads
Sheet 5 of 6

| Time Seq. (s) (13) | Load Description (8) (15) (19) | Volts | Rating (hp/kW) (3) | Alternate Feed Load (kW) (1) (12) | Operating Load LOOP (kW) (1) (12) | Operating Load DBA/ LOOP (kW) (1) (12) |
|---|---|---|---|---|---|---|
| 15 | Emergency power generating building exhaust fan 1 | 480 | 75 hp | | 62.2 | 62.2 |
| 15 | Emergency power generating building exhaust fan 2 | 480 | 75 hp | | 62.2 | 62.2 |
| 15 | Additional connected loads | 480 | 90.9 kW | | 90.9 | 90.9 |
| 15 | Load contribution from transformer and cable losses | | 160 kW | 40 | 120 | 120 |
| Subtotal Load Step Group 1 | | | | 447.3 (10) | 1640.5 | 1678.0 |
| Load Step Group 2 (17) | | | | | | |
| 20 | MHSI pump | 6.9 kV | 700 hp | | | 580 |
| Subtotal Load Step Group 2 | | | | | | 580 |
| Load Step Group 3 (17) | | | | | | |
| 25 | LHSI pump | 6.9 kV | 500 hp | | | 414 |
| Subtotal Load Step Group 3 | | | | | | 414 |
| Load Step Group 4 (14) | | | | | | |
| 30 | CCW pump | 6.9 kV | 1250 hp | | 1036 | 1036 |
| Subtotal Load Step Group 4 | | | | | 1036 | 1036 |
| Load Step Group 5 (14) | | | | | | |
| 35 | ESW pump | 6.9 kV | 1250 hp | | 1036 | 1036 |
| Subtotal Load Step Group 5 | | | | | 1036 | 1036 |

## Table 9-2 Division 1 Emergency Diesel Generator Nominal Loads
### Sheet 6 of 6

| Time Seq. (s) (13) | Load Description (8) (15) (19) | Volts | Rating (hp/kW) (3) | Alternate Feed Load (kW) (1) (12) | Operating Load LOOP (kW) (1) (12) | Operating Load DBA/ LOOP (kW) (1) (12) |
|---|---|---|---|---|---|---|
| Load Step Group 6 (14) | | | | | | |
| 40 | EFW pump | 6.9 kV | 700 hp | | (5) | 580 |
| Subtotal Load Step Group 6 | | | | | (5) | 580 |
| Load Step Group 7 (14) | | | | | | |
| 45 | Division 1 safety chilled water compressor | 6.9 kV | 900 kW | | 1000 | 1000 |
| Subtotal Load Step Group 7 | | | | | 1000 | 1000 |
| Load Step Group 8 (14) | | | | | | |
| 50 | Essential service water UHS fan 1 | 480 | 250 hp | | 207.2 | 207.2 |
| 50 | Essential service water UHS fan 2 | 480 | 250 hp | | 207.2 | 207.2 |
| Subtotal Load Step Group 8 | | | | | 414.4 | 414.4 |
| Subtotal Alternate Feed Loads | | | | 447.3 | | |
| Total Automatically Sequenced Loads without alternate feed installed | | | | | 5127.2 | 6739.5 |
| Total Automatically Sequenced Loads with alternate feed installed | | | | | 5574.5 | 7186.5 |
| Additional Manually Connected Loads | | | | | | |
| | Emergency pressurizer heaters (16) | 480 | 144 kW | | 144 | |
| | Extra boration pump | 480 | 163 Bhp | | 0 (20) | 0 (20) |
| | Fuel pool cooling pump (21) | 480 | 137 Bhp | | 113.6 | 113.6 |
| Total Manually Connected Loads | | | | | 257.6 | 113.6 |
| Total Division 1 EDG Loading | | | | | 5832.1 | 7300.4 |

**Notes:**

1. The kW rating derived from hp rating multiplied by 0.746 conversion factor. Indicated hp is considered rated. Where brake horsepower (Bhp) is indicated, this is from the system mechanical requirements.

2. A diversity factor of 0.7 is assumed in load contribution due to cyclical nature of load.

3. Motor efficiencies estimated at 90 percent.

4. One EUPS battery charger is in service with the other battery charger in standby. Contribution to EDG loading is calculated considering only one battery charger.

5. During a LOOP-only EDG loading sequence, the EFW start is prevented until load step group six, which occurs at 30 seconds. At load step six, the start inhibit is removed and the EFW pump start sequence is based on steam generator low level initiation. If a steam generator low level initiation exists, EFW pump start is given priority over subsequent load steps.
   During a LOOP/LOCA condition, the EFW pump is started at the sequence step indicated.

6. The divisional safety chilled water pump and chiller are assumed operating for EDG loading purposes.

7. Worst case EDG loading occurs during summer operation when safety chilled water loading is highest. Area heater loads are shown, but do not contribute to overall EDG loading since operating conditions where heater operation is expected does not reflect bounding EDG loading scenario.

8. Loads represented in load groups are assumed running during the time duration assumed for accident analysis and mechanical system operational requirements, with the exception of motor-operated valves and dampers. Motor-operated valves and dampers are momentary loads, and are powered within EDG short-term ratings. Manually connected intermittent loads are applied following load sequencing, in accordance with approved operating procedures and their load contributions are within EDG long-term rating.

9. Deleted.

10. Alternate feed loads contributing to EDG loading are shown in the automatic sequenced loads with alternate feed installed totals.

11. Load only operated if control room high radiation signal present.

12. Efficiency estimated at 90 percent for motor loads.

13. EDG output breaker closure of T=15 seconds is an estimated time. Subsequent timing steps are based on EDG output breaker and occur in the sequence time interval after the output breaker closure.

14. During a LOOP-only condition, load steps two, three and six (based on steam generator level) are omitted resulting in the loading of this step earlier than LOOP/LOCA condition.

    A. During a LOOP-only sequence the steps are at the indicated time:

        1. Step 4 20 seconds

        2. Step 5 25 seconds

        3. Step 7 30 seconds

        4. Step 8 35 seconds

    B. If an SI actuation occurs before closure of the EDG output breaker, the LOOP/LOCA sequence is followed.

    C. If an SI actuation occurs after closure of the EDG output breaker, the sequence is interrupted and the DBA/LOOP sequence load steps two through six are performed. Following performance of load step six, the sequence is re-started where interrupted and performed to completion.

15. Loads are safety-related loads, unless otherwise indicated.

16. Non-safety-related load that can be manually applied to the EDG. Contribution to EDG loading from non-safety-related loads is shown in total EDG loading column.

17. Load steps 2 and 3 are started by the load sequencer as indicated by an SI signal. Should a LOOP occur subsequent to starting LOCA mitigation loads, the sequence is reset and restarts at the closure of the EDG output breaker.

18. Non-safety-related load that is automatically applied to the EDG. Contribution to EDG loading from non-safety-related loads is shown in total EDG loading column.

19. The inrush current for motor starting studies during EDG load sequencing is represented by locked-rotor impedance, which draws the maximum possible current from the system and has the most severe effect on other loads. Following the acceleration period, the motors represented in the load step are changed to a constant KVA load.

20. Contribution to EDG loading is not credited in total division 1 EDG loading column as this load is not credited to operate concurrently with MHSI and LHSI at rated power.

21. One fuel pool cooling pump in service, the other pump is in standby. Contribution to EDG loading is calculated considering only the inservice pump.

**Table 9-3—Onsite DC Power System Component Data Nominal Values**
**Sheet 1 of 2**

| Component | Division/Train | Nominal Value |
|---|---|---|
| 1. EUPS Batteries: | Each EUPS Battery | 2.22 V/cell nominal float voltage<br>2.33 V/cell equalize voltage<br>1.215 nominal specific gravity at 77°F |
| | Divisions 1 and 4 | 240 cells<br>1800 AH at eight hour rate to 1.75 V/cell at 77°F (1) |
| | Divisions 2 and 3 | 120 cells<br>2147 AH at eight hour rate to 1.75 V/cell at 77°F (1) |
| 2. EUPS Battery Chargers | Divisions 1 and 4 & Divisions 2 and 3 | Rated nominal input voltage 480 Vac, 3 phase<br>Rated maximum input voltage 508 Vac<br>Rated minimum input voltage 413 Vac<br>Rated nominal AC supply frequency 57 to 63 Hz<br>Rated nominal output voltage 250 Vdc |
| | Divisions 1 and 4 | Required output current 382 A (2) |
| | Divisions 2 and 3 | Required output current 333 A (2) |
| 3. EUPS Inverters | Divisions 1 and 4 & Divisions 2 and 3 | Rated nominal input voltage 250 Vdc<br>Rated maximum input voltage 280 Vdc<br>Rated minimum input voltage 200 Vdc<br>Rated nominal output voltage 480 Vac 3 phase<br>Rated power regulation ± 2%<br>Rated nominal output frequency 60 Hz ± ½%<br>Total harmonic distortion less than 5% total voltage distortion, less than 3% individual voltage distortion |
| | Divisions 1 and 4 | Rated power 450 kVA |
| | Divisions 2 and 3 | Rated power 300 kVA |
| 4. EUPS AC/DC Converters | Divisions 1 and 4 & Divisions 2 and 3 | Rated Nominal input voltage 480 Vac<br>Rated nominal output voltage 24 Vdc |
| 5. EUPS DC/DC Converters | Divisions 1 and 4 & Divisions 2 and 3 | Rated nominal input voltage 250 Vdc<br>Rated maximum input voltage 280 Vdc<br>Rated minimum input voltage 200 Vdc<br>Rated nominal output voltage 24 Vdc |
| 6. EUPS DC Distribution Switchboard | Divisions 1 and 4 | Rated Continuous Current 2500 A<br>Rated Short Circuit Current 39 kA |
| | Divisions 2 and 3 | Rated Continuous Current 2000 A<br>Rated Short Circuit Current 30 kA |
| 7. EUPS AC Distribution MCC | Divisions 1 and 4 & Divisions 2 and 3 | Rated Maximum Voltage, 508 V<br>Maximum Continuous Current, 2000 A<br>Maximum Bus Bracing Current, 100 kA rms |

## Table 9-3—Onsite DC Power System Component Data Nominal Values
## Sheet 2 of 2

| Component | Division/Train | Nominal Value |
|---|---|---|
| 8. 12UPS Batteries | Trains 1 and 2 | 120 cells<br>2.22 V/cell nominal float voltage<br>2.33 V/cell equalize voltage<br>2400 AH at 12 hour rate to 1.81 V/cell at 77°F (1)<br>1.215 nominal specific gravity at 77°F |
| 9. 12UPS Battery Chargers | Trains 1 and 2 | Rated nominal input voltage 480 Vac, 3 phase<br>Rated maximum input voltage 508 Vac<br>Rated minimum input voltage 424 Vac<br>Rated nominal AC supply frequency 57 to 63 Hz<br>Rated nominal output voltage 250 Vdc<br>Required output current 600 A (2) |
| 10. 12UPS System Inverters | Trains 1 and 2 | Rated nominal input voltage 250 Vdc<br>Rated maximum input voltage 280 Vdc<br>Rated minimum input voltage 210 Vdc<br>Rated nominal output voltage 480 Vac 3 phase<br>Rated power regulation ± 2%<br>Rated power 160 kVA<br>Rated nominal output frequency 60 ± ½% |
| 11. 12UPS AC/DC Converters | Trains 1, 2, 3, and 4 | Rated Nominal input voltage 480 Vac ± 2%<br>Rated input frequency 60 Hz ± ½%<br>Rated nominal output voltage 24 Vdc |
| 12. 12UPS DC/DC Converters | Trains 1, 2, 3, and 4 | Rated nominal input voltage 250 Vdc<br>Rated maximum input voltage 280 Vdc<br>Rated minimum input voltage 210 Vdc<br>Rated nominal output voltage 24 Vdc |

**Notes:**

1. Battery amp-hour rating for different discharge rates are in accordance with vendor specific performance characteristic curves.

2. Battery charger current limiter will limit output current to below 150 percent of the full load output current rating.

## Table 9-4 — Station Blackout Continuous Loading – Train 1

| Function | Power | Notes |
|---|---|---|
| Safety Chilled Water Compressor - Division 1 | 530 kW | Division 1 is air cooled. Even if powered, the division 2 compressor does not run, because the component cooling water it requires is not available during SBO. |
| Emergency Feedwater Pump | 580 kW | Nominal load adjusted higher for possible efficiency losses. No credit has been taken for the reduced flow rate and hydraulic load expected during SBO. The value listed is conservative. |
| Class 1E Battery Chargers | 200 kW | Includes division 1 and division 2. |
| Class 1E 480 V Loads<br>Except Battery Chargers -division 1 | 820 kW | Includes 480 V loads powered from load centers 31BMB and 31BMC and MCCs 31BNB01, 31BNB02, 31BNB03, and 31BNC01. |
| Class 1E 480 V Loads<br>Except Battery Chargers-division 2 | 520 kW | Includes 480 V loads powered from load center 32BMB and MCCs 32BNB01, 32BNB02, and 32BNB03. |
| SBO DG Auxiliaries | 230 kW | |
| Non-Class 1E Battery Chargers | 320 kW | Non-Class 1E chargers may be turned off during SBO as needed to maintain load below SBODG continuous rating. |
| Provision for Site-Specific Non-Class 1E Loads | 450 kW | |
| Total SBO Load | 3650 kW | |
| Asset Protection | 940 kW | Load present during LOOP without SBO. Individual loads removed during SBO as needed to maintain load below SBODG continuous rating |